MODIS Quarterly Report January - March 1994

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SUMMARY

1. Accomplishments

- ATBDs: The 4 ATBDs were updated and delivered (in collaboration with C. Justice and D. Tanré, and participation by B.-C. Gao, L. Remer and E. Vermote). The main advances were in the ATBD for remote sensing of aerosol, and in the ATBD for remote sensing of fires. Some new technical aspects of the ATBD for remote sensing of water vapor in the NIR and ATBD for atmospheric corrections were include.

- AEROSOL MODELS: A major thrust of present research is in developing better physical and optical models of aerosol for remote sensing. Ground based measurements during SCAR-A are being analyzed for the aerosol size distribution and related to meteorological parameters. A clear model is emerging. A theoretical model for the dynamical evolution of aerosol size distribution was developed and used to show that the sulfate aerosol effect on cloud microphysics is 4 times larger than postulated in previous works. A paper by Kaufman and Tanré on the issue was accepted for publication in Nature. Measurements in other locations are being acquired (Holben, Tanré and Kaufman in collaboration with many others).

- AEROSOL OVER OCEANS - the algorithm, by Tanré and Kaufman for remote sensing of aerosol loading and size distribution over the oceans is being coded. The emphasize is on use of wide spectral range, till 2.1 μm or 3.9 μm in order to be able to distinguish between the small and large aerosol particles. We believe that this algorithm can have eventual influence on atmospheric corrections over the oceans.

- AEROSOL OVER LAND - First version of the program for remote sensing of aerosol over the land was finished and delivered. We are awaiting response.

- SCAR-A DATA SET - SCAR data set (MAS, AVIRIS, TM, AVHRR) is being acquired, calibration issues resolved, and data prepared for application of MODIS algorithms.

- FIRES - The algorithm for remote sensing of fires was modified to include two main parameters: the total thermal energy emitted from the fire and ratio between the fraction of this energy being emitted from smoldering stage and flaming stage. This is expected to make the algorithm much more useful for the users community (e.g. discussions with the Forest Service Fire Lab scientists). Sensitivity study was done.

2. Future plans:

- SCAR-C experiment - Sept. 1994 California and Oregon to measure fires and smoke.
- First version for software for atmospheric corrections to be delivered May-July
- First version for software for remote sensing of water vapor June-Aug.
- First version for software for remote sensing of fires Oct.-Feb., 1995.
- Sensitivity studies and application of MODIS software to SCAR-A data May-Dec.

Detailed report

1. SCAR -A

We continue to analyze the data collected during the SCAR-A experiment.

1.1 Intercalibration of instruments

Using images observed nearly simultaneously on July 12 by TM and AVIRIS we compared the reflectances measured by the two instruments for 13 targets representing a wide range of reflectances -- from very dark forest and water to bright fields of mostly bare soil. We used the calibration available on the TM data tape for the TM data and integrated the AVIRIS 10 nm bands to resemble the six reflectance bands of the TM instrument. The table below shows the mean ratios of the TM reflectances to the AVIRIS reflectances (r1). The table also shows the mean ratios between a 1992 inflight calibration of the TM instrument to the calibration available on the TM data tape (r2) as reported by Thome et al. (1993).

	r1	r2
TM ch1:	0.985	--------
TM ch2:	0.933	0.818
TM ch3:	0.922	0.849
TM ch4:	0.895	0.952
TM ch5:	0.904	0.929
TM ch7:	1.130	1.041

We plan to normalize the TM observations (and the MAS observations when obtained) to the AVIRIS values for all future work with these data sets.

1.2 Surface reflectance properties in the visible and at 2.1 µm

A TM image of the Great Dismal Swamp area for July 28 was corrected for Rayleigh and aerosol scattering and water vapor absorption using data from the Hampton Roads sunphotometer. Twenty-three targets were chosen from this image including a lake, dark forest, agricultural fields, bare soil, and residential parts of Norfolk. Corrected surface reflectances show that the 2.1 µm surface reflectances are linearly correlated with the visible surface reflectances and that the reflectance at 0.47 µm can be approximated as 25% of the reflectance at 2.1 µm while the reflectance at 0.66 µm is approximately 50% of that at 2.1 µm.

We have identified targets in TM and AVIRIS images in other geographic regions with different terrain and vegetation cover. After the atmospheric correction is completed for these images, our data base of surface properties will be expanded.

1.3 Modeling of atmospheric aerosol using SCAR-A data

We continue to use the size distributions calculated from sunphotometer data, averaged and sorted according to aerosol optical thickness to develop an atmospheric aerosol model representative of the eastern U.S. We compare four days of these data at specific sunphotometer sites with in situ data measured at various altitudes by the C-131A aircraft above the specific sunphotometer. The size distributions from sunphotometer remote sensing show remarkable similarity to those measured in situ by the aircraft. There are still uncertainties in the sunphotometer data for radii less than 0.1 µm and also for very large radii. We hope to reduce these uncertainties for small radii by testing the robustness of our lognormal fits and also by further comparisons with the aircraft data (other variables such as CCN etc.).

The model of the accumulation mode as a function of aerosol optical thickness suggests a change in the physical processes governing aerosol growth at optical thickness equal to 0.20 when the effective particle radius is 0.04-0.05. Further analysis needs to be done to determine the reason for this apparent shift. Other variables, especially moisture variables and cloud fraction will be analyzed as possible factors. We have begun this work by investigating the relationship between several moisture variables and the aerosol optical thickness.

2. Algorithm Development

The revised Algorithm Theoretical Basis Document was completed for the atmospheric corrections for the surface reflectance by E. Vermote and L. Remer with C. Justice, Y.J. Kaufman and D. Tanré. No major changes to the algorithm are proposed in the revised document. The sole product of the algorithm will be the spectral surface reflectance. A research agenda was added to emphasize the need to continue development of specific pieces of the algorithm and validation of the algorithm as a whole.

3. Planning for SCAR-C

The SCAR-C (Smoke Clouds And Radiation - California) field experiment is planned for September '94. The main objective is to collect data for development and validation of the MODIS fire detection and aerosol detection algorithms. On February 16, we met with M. King, C. Justice and representatives from the U.S.D.A. fire research division (D. Ward and W-M Hao) to plan SCAR-C. It was decided to have a pre-set fire in Oregon during 19-30 September '94. Since that meeting P. Hobbs from the Univ. of Washington has indicated that his group would like to participate in the experiment with us. We decided to extend our ER-2 flight hours due to the participation of P. Hobbs' group and the larger scope that the experiment has undertaken. We would also like to increase the duration of the experiment by beginning the experiment earlier in September. Moving SCAR-C earlier depends on the availability of the ER-2 which is committed to BOREAS until 19 September; however, there is a possibility that BOREAS will cancel their September flight hours. If they do cancel, they will not cancel until August. This requires some flexibility on our part.

4. MODIS 1.375-µm channel

We are writing a paper on selection of the MODIS 1.375-µm channel for remote sensing of cirrus clouds from space and on its application. The paper will be submitted to J. Atmos. Sci. in June, 1994.

5. Remote sensing of liquid water

Development of a new index, called the normalized difference water index (NDWI), which is a good measure of the information about liquid water content of vegetation canopy. The MODIS near-IR channels centered at 0.865 and 1.24 µm are used. Both channels are located in "atmospheric window" regions. NDWI is defined, similar to the definition of the widely used normalized difference vegetation index (NDVI), as:

$$NDWI = [\rho^*(0.865\ \mu m) - \rho^*(1.24\ \mu m)] \ / \ [\rho^*(0.865\ \mu m) + \rho^*(1.24\ \mu m)],$$

where ρ^* represent apparent reflectance (after correction of weak Rayleigh scattering effect for the 0.865-µm channel, and no Rayleigh correction is needed for the 1.24 µm channel). Solar radiation at 0.865 µm is strongly reflected by vegetation canopies. Solar radiation at 1.24 µm is weakly absorbed by vegetation liquid water. Both the 0.865 and 1.24 µm channels are not saturated when the leaf area index (LAI) is relatively large (4 or greater). As a result, NDWI is a very sensitive index for measuring the liquid water content of vegetation canopies.

The red channel (~0.65 µm) used in NDVI is saturated when LAI reaches 1, because the red channel is located near the center of the strong vegetation chlorophyll absorption band. NDWI overcomes this saturation problem. Combinations of NDVI and NDWI can provide improved descriptions of the status of vegetation canopies.

The values of NDWI are positive for areas covered by green vegetation, and mostly negative for areas covered by dry vegetation and soils. We have compared images of NDWI and NDVI derived from spectral images acquired with the NASA/JPL Airborne Visible/Infrared Imaging Spectrometer (AVIRIS). NDWI does overcome the saturation problem of NDVI.

Note that NDWI is expected to be much less dependent on aerosol effect than NDVI. This is a result of the longer wavelegths (aerosol effect is on average inversely proportional to the wavelegth) and due to the higher surface reflectance in these channels than in the red channel. The aerosol effect is minimal, close to zero for surface reflectace in the range 0.2-0.3 (the range depends on the aerosol singlescattering albedo).

6. Aerosol effect on radiative forcing and climate

SCAR-A data were used to derive the aerosol scattering phase function and from that the backscattering by aerosol of sunlight back to space. This scattering may cause the climate system to cool or decrease the greenhouse warming. Results were presented n the AMS conference.

7. EFFECT OF VARIATIONS IN SUPERSATURATION ON THE FORMATION OF CLOUD CONDENSATION NUCLEI paper by Kaufman and Tanré (*Nature in press*).

Abstract:

Sulfate aerosols can cool the climate by increasing the concentration of cloud condensation nuclei (CCN) and forming more reflective clouds. The magnitude of this effect is very uncertain. Recent calculations indicate that at most 6% of the anthropogenic sulfur emission forms new particles, while 44% adds mass to existing sulfate particles activated in clouds. It was assumed that sulfate added to existing particles does not increase the CCN concentration because, for a fixed supersaturation, those particles were already CCN. This implies that previous assessments of the sulfate effect on climate by cloud modification were overestimated. Although it was proposed that sub-CCN-size particles can grow to CCN-size in clouds, this was thought to require large supersaturations present in cumuliform clouds rather than in marine stratiform clouds that are most important for radiative forcing. Here we show that variability of even low average supersaturations allows particles as small as 0.015 μm to grow and become CCN. This process can quadruple the concentration of CCN and increase the corresponding aerosol effect on climate.

8. Meetings

Bo-Cai Gao, Yoram Kaufman and Lorraine Remer attended the AMS conference in Nashville TN, 24-26 January.

References

Thome, K. J., S. F. Biggar and P. N. Slater, 1993: Recent absolute radiometric calibration of Landsat-5 TM and its application to the atmospheric correction of ASTER in the solar reflective region. In *Proceedings of the Workshop on Atmospheric Correction of Landsat Data, Torrance CA* , General Dynamics Corp., Torrance CA, 36-40.

Publications

A paper by Gao et al., "Extraction of Dry Leaf Spectral Features from Reflectance Spectra of Green Vegetation", was published on *Remote Sens. Environ., 47: 369-374* (1994).

Gao co-authored a paper (with K. D. Hutchison and K. R. Hardy), "Improved detection of optically-thin cirrus clouds in nighttime multispectral meteorological satellite imagery using total integrated water vapor information", and submitted the paper to *J. Appl. Meteor.* in March, 1994.

Accepted / submitted for publication:

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A. Karnieli, M. Shachak, H. Tsoar, E. Zaadi, Y. Kaufman, A. Danin, W. Porter, 1994: 'The effect of microphytic communities on satellite spectral reflectance of arid and semi-arid regions', submitted to Science.